

**Geospatial Information System (GIS) Analysis of
Florida Keys National Marine Sanctuary Fishing Panels**

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Introduction

Since 1997, the Florida Keys National Marine Sanctuary (FKNMS) has implemented a network of no-take zones, consisting of ecological reserves, sanctuary preservation areas, and special-use areas. The socioeconomic effects of these zones have been addressed for the commercial fishing industry (Milon et al., 1997; Suman, Shivlani, and Milon, 1999), dive operators (Shivlani and Suman, 2000; Suman and Shivlani, 1998), and local communities (Suman, Shivlani, and Milon, 1999). More comprehensive efforts have been focused on the Dry Tortugas commercial fishery (NOAA, 2000; Shivlani, Suman, and Murray, in preparation). However, most of these studies have represented a “snapshot” of the socioeconomic effects resulting directly from FKNMS management and less directly from the FKNMS no-take zones. By contrast, our research and monitoring program tracks the commercial fishing industry over time and across fisheries and regions. The program, divided into four distinct fishing panels, determines the long-term effects of marine zoning on commercial fishing, including changes in catch, effort, costs, investments, and attitudes and perceptions concerning marine resources.

In its fourth year of research, the project has continued with the collection of spatial data. Specifically, we have developed a Geospatial Information System (GIS) framework to collect fishery spatial data through field surveys, link that data into existing base maps for the FKNMS, and to then analyze the importance of spatial distribution with a variety of parameters, including distance from fishing port, boundary fishing around no-take zones, and fishing by bottom type, gear type, and species. Although the first two years’ worth of data are by themselves useful in descriptive analysis, we believe that a multi-year collection database will provide invaluable information on the long-term effects of no-take zones on fishing activities, as well as identifying inter-annual patterns in catch and effort.

The results presented in this report are indicative of all four panels used in the survey effort: Dry Tortugas, Sambos, General, and Marine Life fishery panels; the data depicted in the maps are based on the 1999-2000 and 2000-01 seasons. The data is limited to the entire sample, as the intent of this report is illustrative (although we expect to perform both panel-based and regional analyses, as well as stratified mapping, in future efforts). The maps created, using GIS, depict total catch by species, with the exception of marine life collectors, for the entire FKNMS. All data collected for outside the FKNMS has been cropped. Each map is described in a separate section.

Total catch in the FKNMS

The spatial information provided represents the data of 22 panel members in the 1999-2000 season, and 26 panel members (including four alternates) in the 2000-01 season. Two panel members dropped out of the sample (one each from the Sambos and Tortugas panel, due to their health reasons), and their data was replaced by persons who fish in very similar areas (and target the same species). Overall then, it must be noted that the inter-annual comparisons may represent fine resolution changes in fishing patterns among

panel members; however, it must also be emphasized that panel members were replaced (or added as alternates) due to their fit in the panels which themselves are partially based on geographical representation.

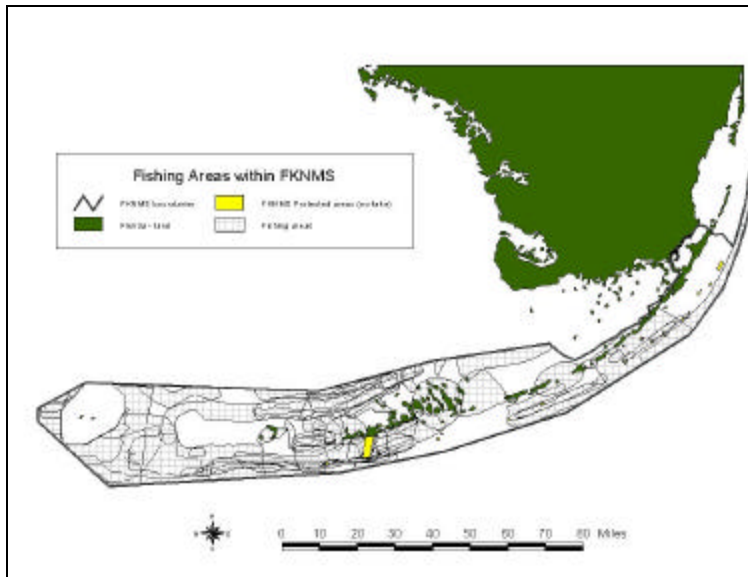


Figure 1: Fishing areas in the FKNMS: 1999-2000



Figure 2: Fishing areas in the FKNMS: 2000-01

Fishing areas from the 1999-2000 to the 2000-01 seasons did not change much. It does appear that the fishers targeted more areas in the latter season, as most of the FKNMS was utilized by commercial fishing activities. Also, it is clear from both seasons that there is extensive use around the FKNMS no-take zones. This is especially important for

the next season's data collection (2001-02), as that season represents the first year during which Tortugas fishers will have been excluded from the Dry Tortugas Ecological Reserve (effective as of July 2001).

Even though total fishing coverage appears to have remained similar between the 1999-2000 and 2000-01 seasons, there were some interesting spatial patterns for individual species that might demonstrate tenure systems for some species and opportunistic effort for others. These patterns are described for each major species landed by panel members, below.

Spiny lobster catch in the FKNMS

Overall, the 1999-2000 lobster fishing map represents 12 (54.5%) panel members, of which eight fish in the Lower Keys. Five belong to the General panel, three each to the Tortugas and Sambos panel, and there is one marine life panel member. Almost 81% of the lobster catch reported by the panels was landed in the FKNMS. The 2000-01 represents 16 (61.5%) panel members, of which 13 fished the Lower Keys. Six belong to the General panel, five to the Tortugas panel, four to the Sambos panel, and there is one marine life panel. It should be noted that there are more panel members that reported landing spiny lobster in both years, but these persons either did not provide exact landings data or did not specify the locations fished. In 2000-01, almost 90% of the total catch was landed within FKNMS waters.

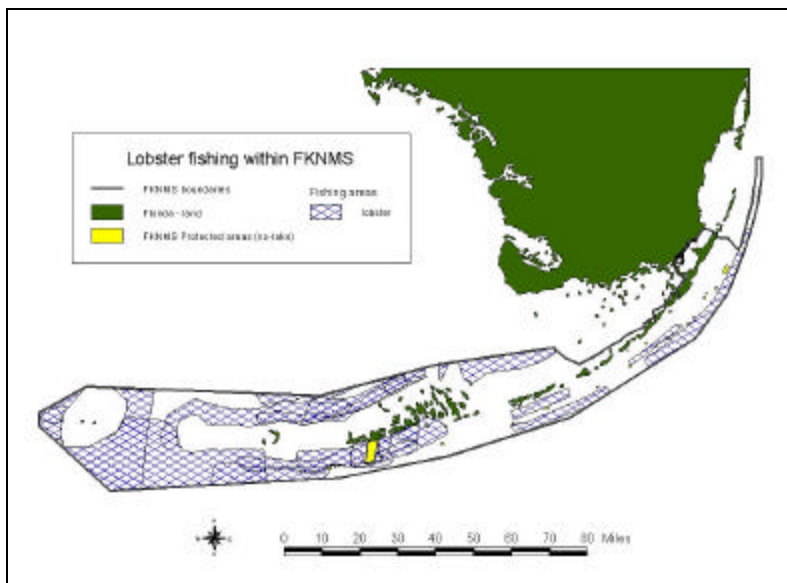


Figure 3: Spiny lobster catch: 1999-2000

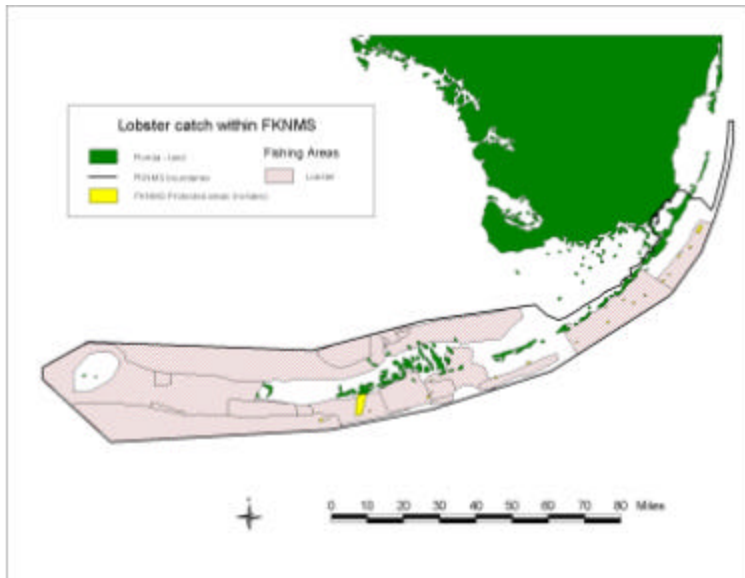


Figure 4: Spiny lobster catch: 2000-01

As is evident in both fishing seasons, spatial catch locations are concentrated along the western parts of the FKNMS. In 1999-2000, the Tortugas region accounted for over 46% of the catch; in 2000-01, however, the Tortugas region only accounted for 21.4% of the catch, even though 90% of the lobster landed that season was landed from inside the FKNMS (compared to 81% in 1999-2000). Instead, areas between the Middle Keys and Key West (accounting for over 21% of the total catch in the FKNMS, compared to 11.4% in the previous season) and the region between Key West and the Tortugas (accounting for over 43% of the total catch in the FKNMS, compared to 16.5% in the previous season) were more important in the 2000-01 season. This suggests that there must be significant movement of traps during a season, even in fishing areas as remote as the Tortugas. Interestingly, when comparing catch for the two seasons, it is noted that the shallow region between the Marquesas and Key West is not generally fished for lobster. Also, there is considerable fishing activity around the no-take zones, especially along the boundaries of the larger Sambos Ecological Reserve. Finally, it is observed that lobster fishing, for the most part, continues to occur as a local activity; that is, fishers, with the exception of the Tortugas fleet, generally fish in their immediate location. This is especially true for the Sambos panel members, who reported fishing in and around the Sambos area (a 15 mile swath around Key West) for a majority of their lobster trapping. The following year's data shall examine the spatial effects of the DTER closure, and whether that forces effort eastward, or whether those fishers extend their activities further westward and northward into the Gulf of Mexico.

Marine life collection in the FKNMS

Marine life collectors represent 3 (11.5%) of the panel members for the 2000-01 season, compared to 5 (22.7%) members from the previous season. It is anticipated that the data not obtained from the other two members shall be collected and added to the 2000-01

map prior to the completion of the GIS Year 3 report. All of the marine life collectors represented for the 2000-01 season are based in the Upper Keys, and all of the collection reported by the group for both seasons occurs exclusively within FKNMS waters. In fact, it is the only group, for both years, that does not extend into non-FKNMS waters.

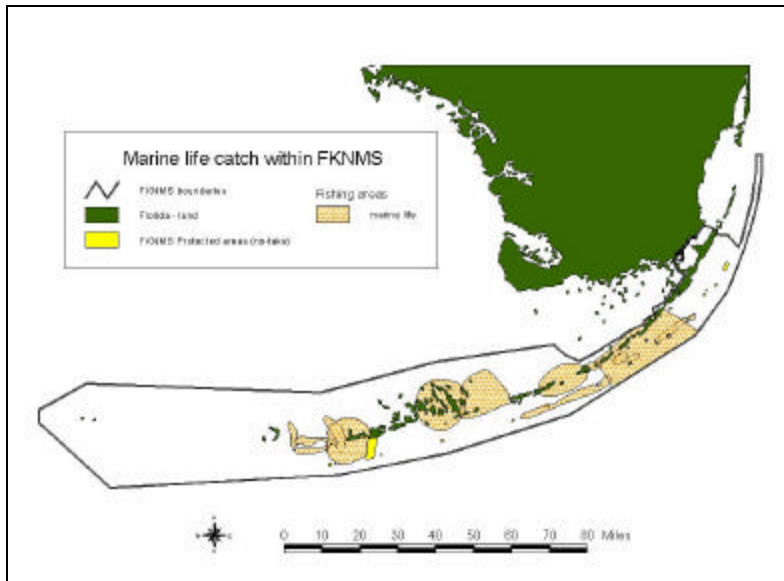


Figure 5: Marine life catch: 1999-2000

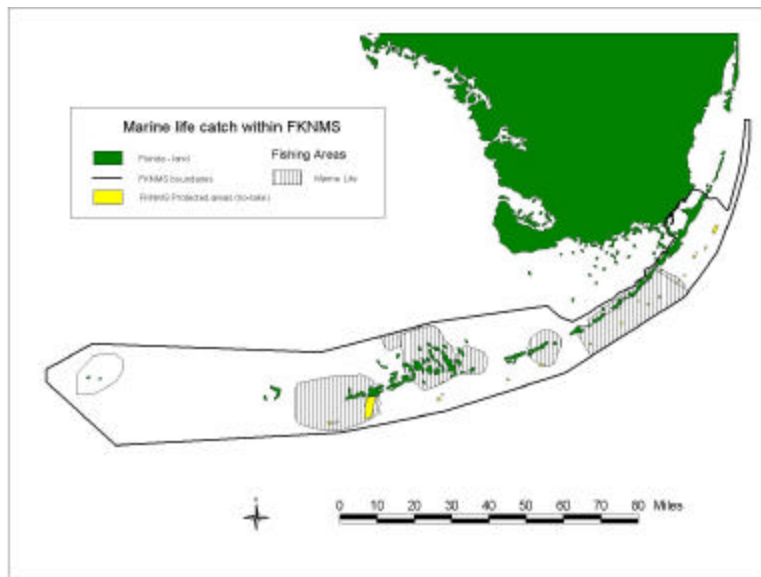


Figure 6: Marine life catch: 2000-01

Marine life collectors display very consistent fishing trends, in that they appear to use, at least in the first two years of spatial data collection, very similar areas on an inter-annual basis. While this does not necessarily denote a form of tenure, it does suggest that there are areas of inter-annual productivity, or so-called hot spots, on which collectors

disproportionately rely. Their effort in both seasons is concentrated around the islands and certain no-take zones. Hot spots include Hawks Channel (off Key West), the area around the Sand Key-Rock Key-Eastern Dry Rocks SPA complex up to the Sambos Ecological Reserve, the Content Keys, the bridges in the Upper Keys, and the reef complex (including areas around the SPAs) off the Upper Keys. Also, as mentioned in the previous report, it is difficult to discern the bottom habitat types used by the sample due to the large number of species they target. However, due to the fact that marine life collectors generally dive for their species, it can be assumed that most the bottom habitats utilized include coral reef, hard bottoms, sea grasses, and sandy bottoms.

Reef fish catch in the FKNMS

A total of six panel members (23.1%) reported landing reef fish, compared to four panel members in 1999-2000. Four of the members belong to the Tortugas Panel, and one each to the Sambos and General Panels, and all of the fishers are located in the Lower Kyes. Only four panel members (18.1%) reported landing reef fish. Two each belong to the Sambos and Tortugas panels. Unlike in 1999-2000, when 58% of the reef fish landed was harvested from within the FKNMS, in 2000-01, almost all the reef fish (98.0%) was landed in the FKNMS.

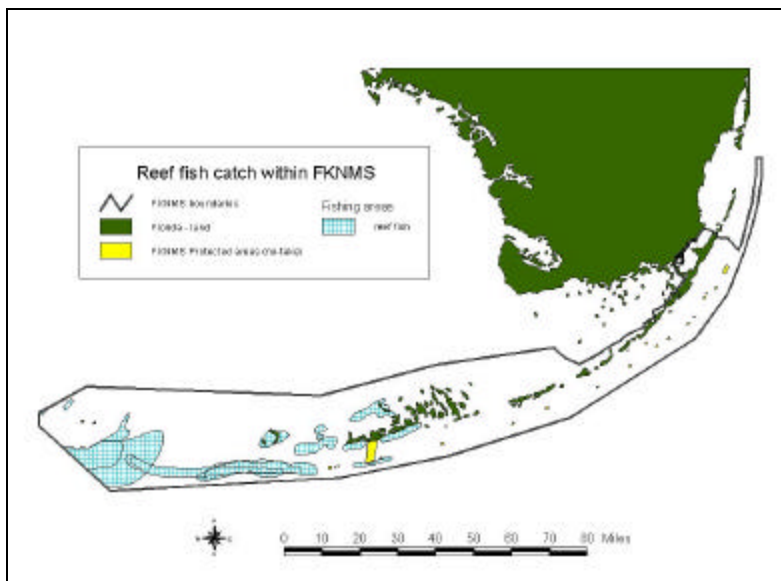


Figure 7: Reef fish catch: 1999-2000

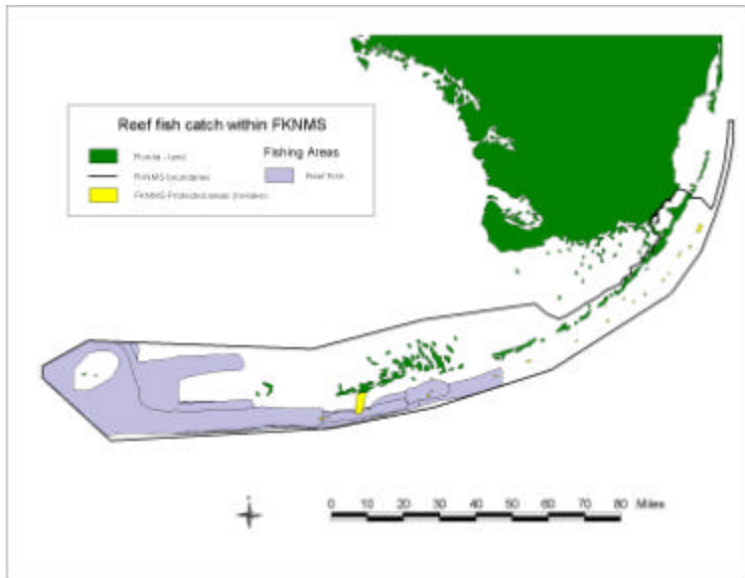


Figure 8: Reef fish catch: 2000-01

As evident in Figures 7 and 8, reef fish catch was landed along the same regions in both years. However, the Tortugas region, which accounted for over 30% of the total catch in 1999-2000, was more important (41%) in 2000-01. The most important region, in terms of total catch, was the area between the Tortugas and Key West, which accounted for almost 52% of the total catch. Areas between Key West and Long Key yielded over 5% of the reported catch. Interestingly, as in the previous year, there was no catch reported by the panel members in the Upper Keys. Also, unlike in 1999-2000, when use in the Tortugas was restricted to the southern half of the region, panel members reported using the entire Tortugas region in 2000-01. While it may be argued that this reporting suggests over-representation by panel members to demonstrate the importance of the region, it is important to note that the Dry Tortugas Ecological Reserve (DTER) and its boundaries were already defined at the time of data collection. Therefore, panel members would not necessarily gain any strategic advantage by misreporting the areas fished in the region. Instead, the differences in catch profiles suggest the inter-annual variability in the importance of the Tortugas region for reef fish (and other important, commercial species). Boundary fishing continued in the 2000-01 season, especially around the Lower Keys no-take zones. Fishers reported targeting reef fish around the Sambos ER (concentrating on the southern third of its boundary) and surrounding SPAs and SUAs. Interestingly, in both years, use was primarily restricted to the South Atlantic side of the Lower Keys. Also, use increased further eastward in the 2000-01 season, reaching as far east as Sombrero Reef SPA off the Middle Keys.

Shrimp catch in the FKNMS

Shrimp harvest data for the 2000-01 included all three shrimpers who participate as part of the Tortugas panel (the 1999-2000 data was incomplete, as it only included information from one shrimper). However, it must be added that although the data are

comparable, due to the relative paucity of shrimping habitat in the FKNMS east of the Tortugas, the Key West representative on the Tortugas panel had to be replaced, as the previous fisher passed away in 2001.

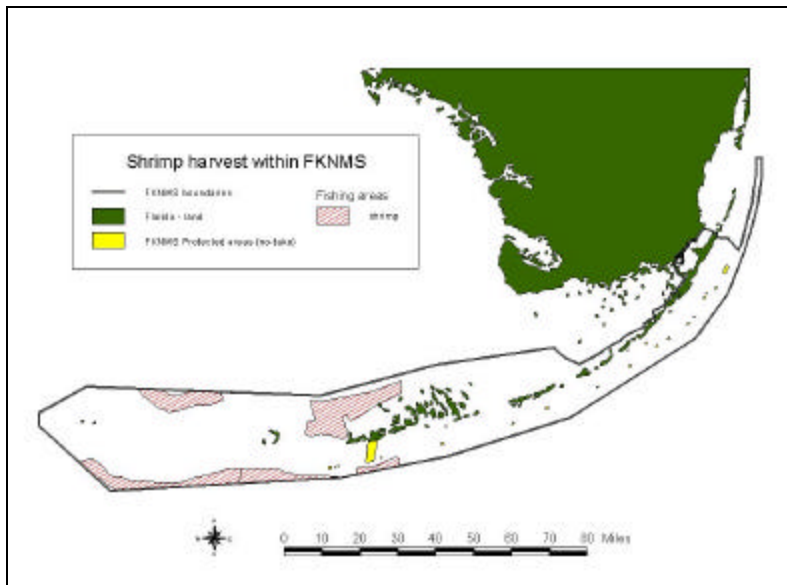


Figure 9: Shrimp catch: 1999-2000

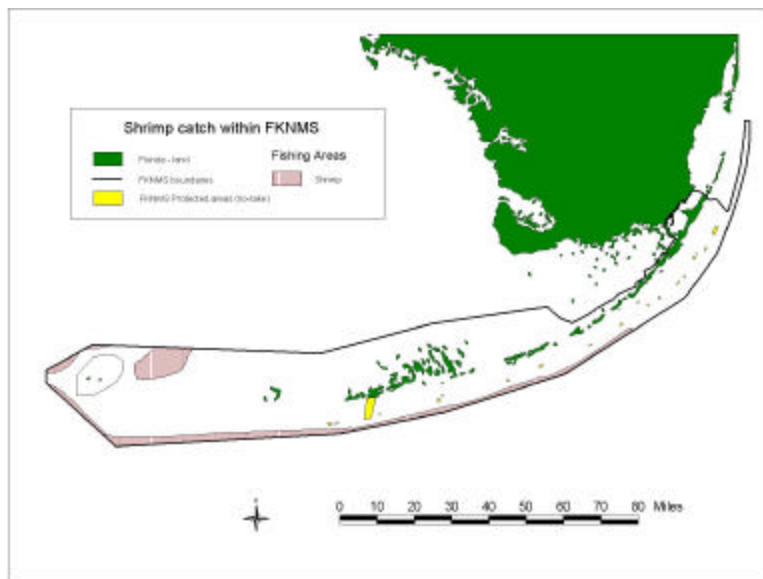


Figure 10: Shrimp catch: 2000-01

The shrimp harvest shown for both seasons demonstrates that the FKNMS does not contain many shrimping areas, and most of the grounds shrimped are along the southern boundary of the FKNMS and the western and northern portions of the Tortugas. In 2000-01, over 71% of the catch reported by the shrimpers was landed in the Gulf of Mexico north and west of the FKNMS. Only 4% was landed along the southern boundary within FKNMS. The majority of shrimp landed within FKNMS waters was harvested in the

Tortugas region, which accounted for almost 24% of the landings. The shrimping areas depicted along the southern boundary of the FKNMS for both seasons is typical of local (Key West) shrimpers who know the region very well. Other, seasonal shrimpers generally avoid these areas, preferring to trawl the northern and western parts of the Tortugas in waters deeper than 120 feet on a seasonal basis. Nevertheless, use can be very concentrated in the Tortugas region and, as indicated by the two shrimpers on the Tortugas Panel, the area is very important periodically to all regional shrimp trawlers.

Spanish mackerel catch in the FKNMS

In 1999-2000, only one person – a Sambos panel member – reported netting Spanish mackerel in federal waters (as gillnet fishing has been banned in State of Florida waters since 1995). In 2000-01, five fishers, including three Tortugas panel members and two Sambos panel members landed Spanish mackerel. Of these, only one fisher used nets to target Spanish mackerel; the others used hook-and-line gear.

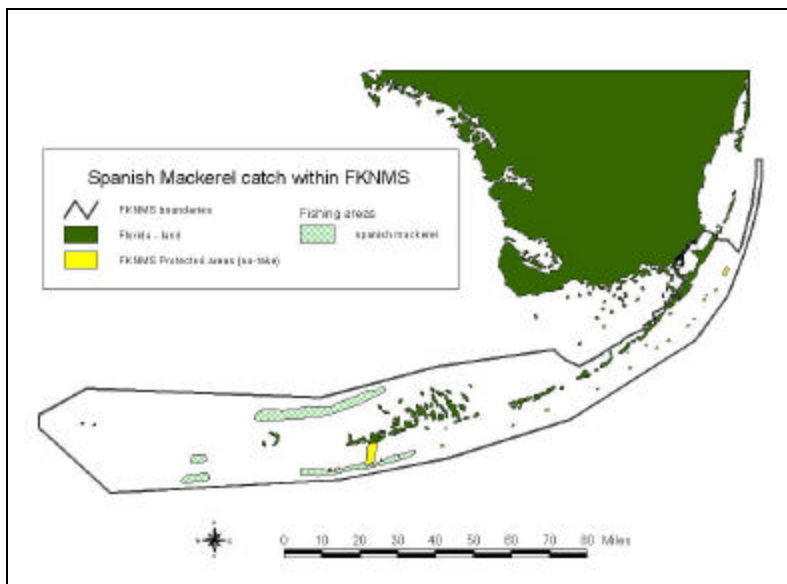


Figure 11: Spanish mackerel catch: 1999-2000

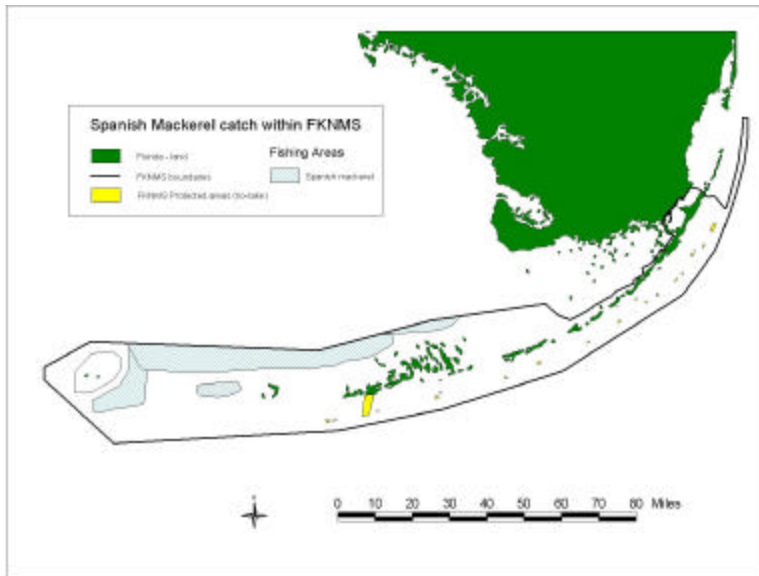


Figure 12: Spanish mackerel catch: 2000-01

Whereas Spanish mackerel was mostly targeted in narrow bands north and south of the Lower Keys by panel members in 1999-2000, it was almost exclusively harvested in Gulf of Mexico waters in 2000-01. Most of the catch in FKNMS waters (38%) was landed in the region between the Tortugas and Key West, north of Rebecca Shoal and the Marquesas. Another 5.5% was caught north of Key West eastward towards the Content Keys. Only 1% was landed in the Tortugas, and there was no catch reported in the Middle or Upper Keys. Because of the aforementioned net ban, most of the effort in the fishery has shifted into federal waters north of the FKNMS, which accounted for over 55% of the total catch in 2000-01. Also, it should be noted that the within-FKNMS catch represents mostly one gear type, hook and line, whereas the outside-FKNMS landings are almost all net-caught fish. Finally, even though the Tortugas area now comprising the DTER did not supply any Spanish mackerel, several panel members did comment that they have targeted the DTER in past seasons for Spanish and king mackerel.

Stone crab catch in the FKNMS

Stone crab is among the most important commercial species in the Florida Keys on a perennial basis. Because it is generally landed in distant (greater than 10 miles) Gulf of Mexico waters by our panel members (who tend to fish further), catch is restricted to the northern edges of the FKNMS. In 1999-2000, four panel members (18.1%) of the group, all from the General Panel, reported landing stone crabs. Of these, only two members fished within the FKNMS. In 2000-01, seven panel members (26.9%) of the group landed stone crabs, including General, Sambos, and Tortugas panel members. Whether the impetus to concentrate in stone crab fishing was related to the then-impending stone crab certificate program is uncertain, but there was certainly both an increase in effort and in the number of participants among our sample.

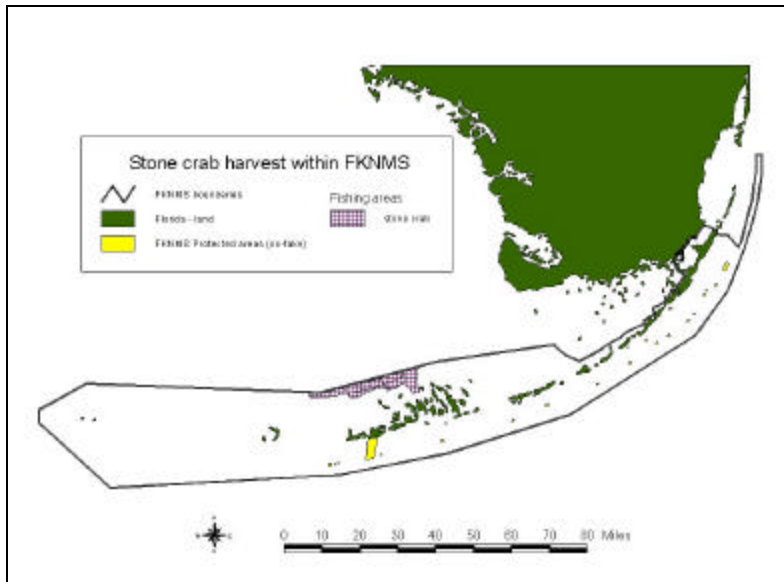


Figure 13: Stone crab catch: 1999-2000

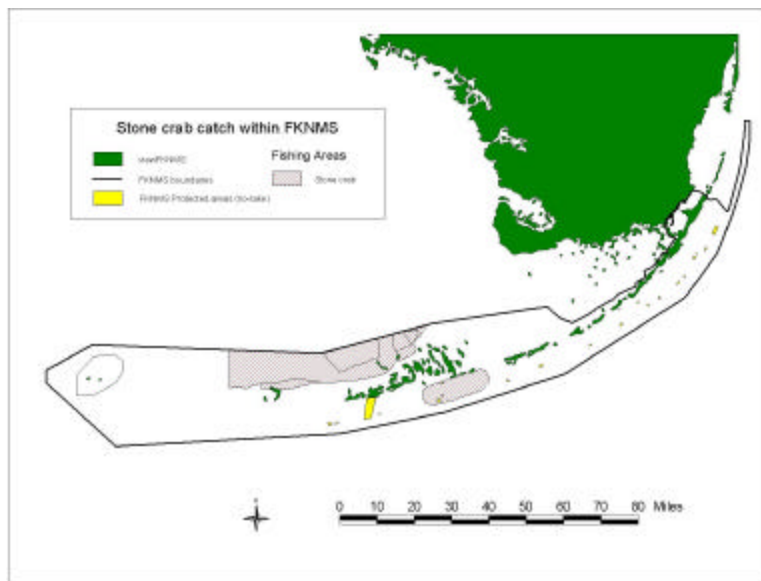


Figure 14: Stone crab catch: 2000-01

Stone crab catch within the FKNMS increased from the 1999-2000 season to the 2000-01 season. Almost 45% of the total catch was harvested within FKNMS waters in the 2000-01 season (compared to only 33% in the previous season). Along with the increased effort within FKNMS waters, panel members also expanded their fishing areas within the FKNMS. In the previous season, traps were placed mostly from north of Key West to the western Content Keys, in the Lower Keys. In 2000-01, however, traps were placed further south (reaching some of the Lower Keys themselves) and westward into the Marquesas, and catch was reported on the Atlantic side off the Lower Keys, including around the Looe Key SPA, Looe Key SUA, and Newfound Harbor Key SPA. However, as determined in previous research (Shivlani et al., in preparation) and from the 1999-

2000 sample, no stone crab harvest is reported from the western portions of the Florida Keys (in the Tortugas, specifically). Also, while there was some effort on the Atlantic side in the Lower Keys, most of the catch is harvested along the Gulf of Mexico side (and in non-FKNMS waters). As stone crab becomes more important to our panel members (due to regulatory pressures on the stone crab and other fisheries, it is predicted that their catch totals may increase within FKNMS waters in future collection years.

King mackerel catch in the FKNMS

King mackerel, or “kingfish” as it is called by most fishers in the Florida Keys, is an important highly migratory species for both net fishers and hook and line fishers. In 1999-2000, only one panel member reported landing king mackerel in the Tortugas within the FKNMS. In 2000-01, a combination of nine Tortugas and Sambos panel members reported harvesting king mackerel within the FKNMS. As demonstrated with other species, king mackerel is an important species to especially Lower Keys fishers; however, its importance depends on inter-annual availability, which is then set as quotas. The panels include several members that target king mackerel using nets and hook and line.

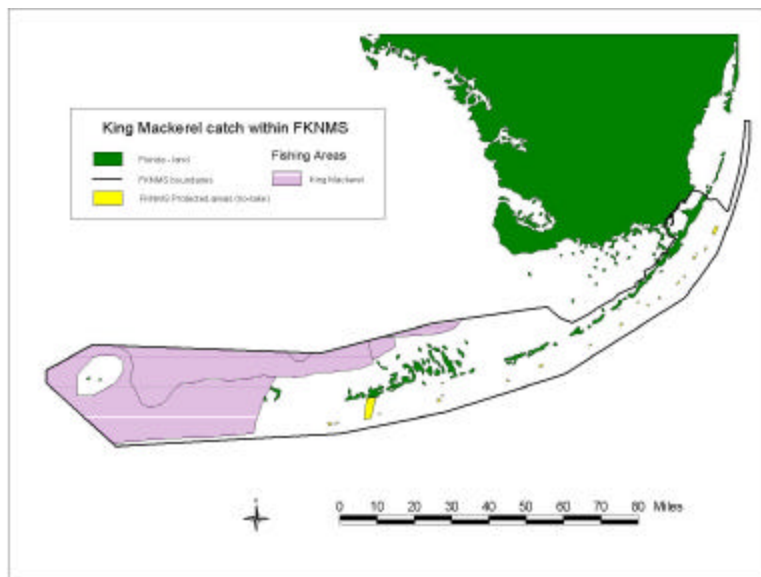


Figure 15: King mackerel catch: 2000-01

As demonstrated in Figure 15, king mackerel was landed in much of the western portion of the FKNMS, as well as the northern sections of the Lower Keys. The catch within the FKNMS represents almost 54% of the catch, of which 28.8% was harvested from the Tortugas region, and 26% from the region between the Tortugas and Key West. However, it must be noted that some catch must have been landed from north of the Content Keys but was erroneously coded as catch from regions further west (i.e. the northern waters above Key West through the Marquesas). Further data collection will assist in the improvement of determination of fishing areas. Finally, as is evident in

Figure 15, king mackerel catch may be affected significantly by the closure of the DTER. Several Tortugas panel members rely on king mackerel catch from within the now-closed DTER, and it will be interesting to evaluate the overall, spatial effects of the zone closure in the third year of data collection. Other FKNMS no-take zones apparently do not affect the harvest of king mackerel, as a majority of the fishing effort occurs in the Gulf of Mexico.

Pelagic and baitfish catch in the FKNMS

Very few panel members target pelagic species within the FKNMS. Two members target golden crab, a deepwater crustacean, in waters deeper than 200 meters off the Atlantic side of the FKNMS. Others fish for pelagic finfish, including tuna, cobia, and amberjack outside both the northern and southern boundaries of the FKNMS. One member of the General Panel targets amberjack every year off the Upper Keys, but his efforts are entirely concentrated in areas outside the FKNMS. Another fisher, of the Tortugas panel, fishes for dolphin along the reef edge (at the southern boundary of the FKNMS) in the Lower Keys. His activities are graphically depicted in Figure 16 below.

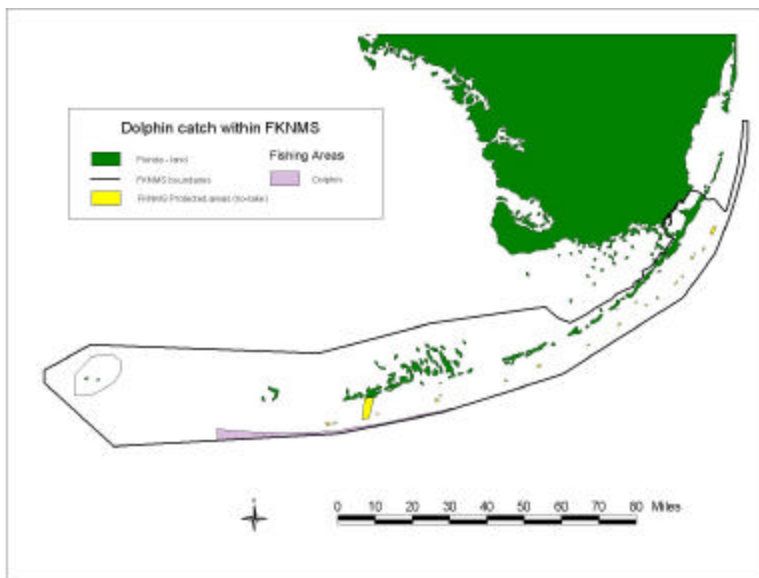


Figure 16: Dolphin catch: 2000-01

The only other group of species targeted by the panel members on an inter-annual basis has been baitfish (consisting of blue runners, ballyhoo, etc.) that are either sold to fish processors or are used as bait for other species. The species recorded in this section are those that are caught and commercially sold. A total of four panel members, consisting of three Tortugas panel members and one Sambos panel member, targeted baitfish in 2000-01. Since baitfish are primarily a shallow water group, almost all of the catch was landed in FKNMS waters.

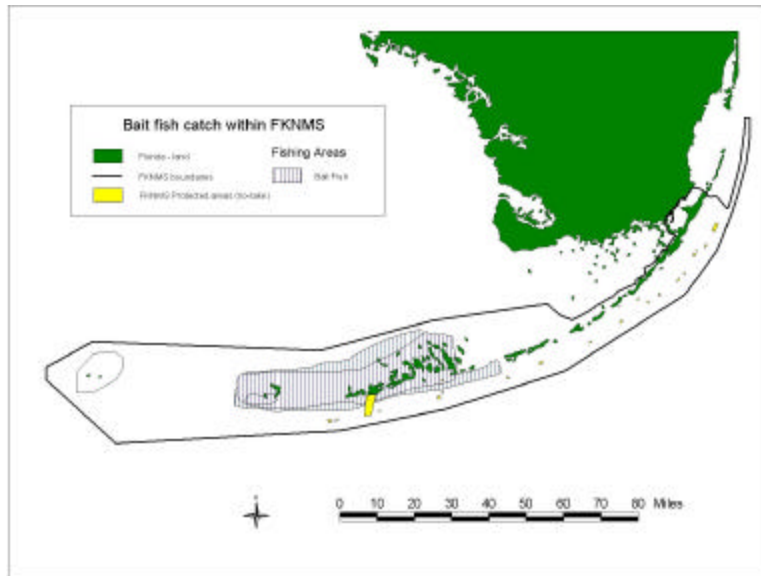


Figure 17: Baitfish catch: 2000-01

Areas of importance included the Lower Keys and parts of the Middle Keys. Most of the catch was obtained from the Lower Keys, between Key West and the Marquesas (over 85%); however, the region between Key West and Long Key did contribute almost 7% of the total catch. Although not depicted in the Figure 17, almost 7% of the remaining catch was landed in parts of the Tortugas; that information was not made available by the fisher, but it shall be collected in the future to determine which parts of the FKNMS' western region are important for the baitfish industry. Previous research in the fishery has determined that certain operations target baitfish well beyond the western edge of the FKNMS (see Shivrani et al., 1998).

Discussion

It is important to emphasize, prior to commencing on a brief discussion, that the data and results described above are both based on a panel member sample (that is not representative of the population) and are preliminary (being part of a pilot mapping project). Future efforts (discussed below) will build on these findings, leading to comprehensive, inter-annual analyses. To add to this qualification, it must be stated that a minimum of a three-year comparison is necessary to determine trends within individual fisher activities, which can then be mapped for the first three years of the program to determine changes in the fishing patterns and to correlate those changes with regulatory and environmental phenomena.

Our preliminary results, from both the 1999-2000 and 2000-01 seasons, suggest that panel member fishing areas in the FKNMS are largely determined by proximity to home ports, with the exception of the Dry Tortugas fishery and certain species (stone crab and king mackerel, in particular, and spiny lobster, occasionally). Further analyses, conducted by comparing vessel size, gear investments, and annual expenses, may assist

in determining if and to what extent economic capitalization affects fishing distance. Also, fishing is quite prevalent around no-take zones, especially the ecological reserves and the Lower Keys SPA complex of Eastern Dry Rocks, Rock Key, and Sand Key. Many of the species (especially lobster, reef fish, and marine life) are harvested near the boundaries of these no-take zones. The Dry Tortugas Ecological Reserve is a major fishing ground for panel members who participate in lobster fishing. Marine life collection occurs exclusively in the FKNMS, and it is often concentrated in areas near no-take zones, including the smaller SPAs in the Upper Keys. Also of importance in the two year comparison has been the findings that any single year description only represents a “snapshot” of spatial fishing effort. Due to changes in regulatory conditions, financial solvency, and environmental conditions (and perhaps a complex combination of all three factors), fishers decide to expand or contract their fishing areas and activities. For example, in the 1999-2000 season, the survey found that only a few of the total eligible panel members fished for stone crab. In the following year, due perhaps to regulatory conditions, effort in stone crab expanded both spatially (in terms of areas used) and in terms of the fishers actively involved in the industry.

Methodologically, the mapping project has continued to demonstrate that we can collect useful, accurate information on various fisheries from panel members. Most importantly for the second year, the mapping data has demonstrated that there is consistency of use within certain fisheries, suggesting data reliability; in other fisheries, the changes in fishing patterns has shown that there is considerable movement in the effort, even within the same users on an inter-annual basis. Although the maps above only demonstrate spatial catch information, we have collected corresponding spatial information on effort, costs, and gear. We have encountered problems with data collection in the field, and we need to improve the accuracy of the information provided by panel members. Specifically, a few panel members have confused certain boundaries on the maps that we have used. In future efforts, we will use more regional maps with detailed relief, markers, and other distinguishing features. We will also use trip-ticket information to obtain more accurate catch totals and cross-reference fishing areas.

Finally, as stated in the previous report, it is reiterated that the spatial data can and should be combined with existing physical and biological maps, including those depicting currents, benthic habitats, fish spawning sites, and others. By combining these sets, we can determine the importance of physical and biological parameters on areas fished, as well as to evaluate whether the biological benefits of no-take zones translate into greater fishing success around those areas. This, along with analysis of individual fishers for the three-year collection period, should constitute the focus of future data interpretation and analysis.

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